(12) UK Patent Application (19) GB (11) 2 259 373 (13) A

(43) Date of A publication 10.03.1993

(21) Application No 9218601.4

(22) Date of filing 02.09.1992

(30) Priority data
(31) 07/756926 (32) 09.09.1991 (33) US

(71) Applicant
Panavision International LP

(Incorporated in the USA - Delaware)

18618 Oxnard Street, Tarzana 91356, California, United States of America

(72) Inventors
Iain Alexander Neil
Albert Kazuo Saiki

(74) Agent and/or Address for Service
J A Kemp & Co
14 South Square, Gray's Inn, London, WC1R 5LX, United Kingdom

(51) INT CL[5]
G02B 7/02, H04N 5/225

(52) UK CL (Edition L)
G2J J23A
H4F FD27A2 FD27C1 FD27R1 FD27T1 FD27T2 FD83B FD83C FJL
U1S S2222

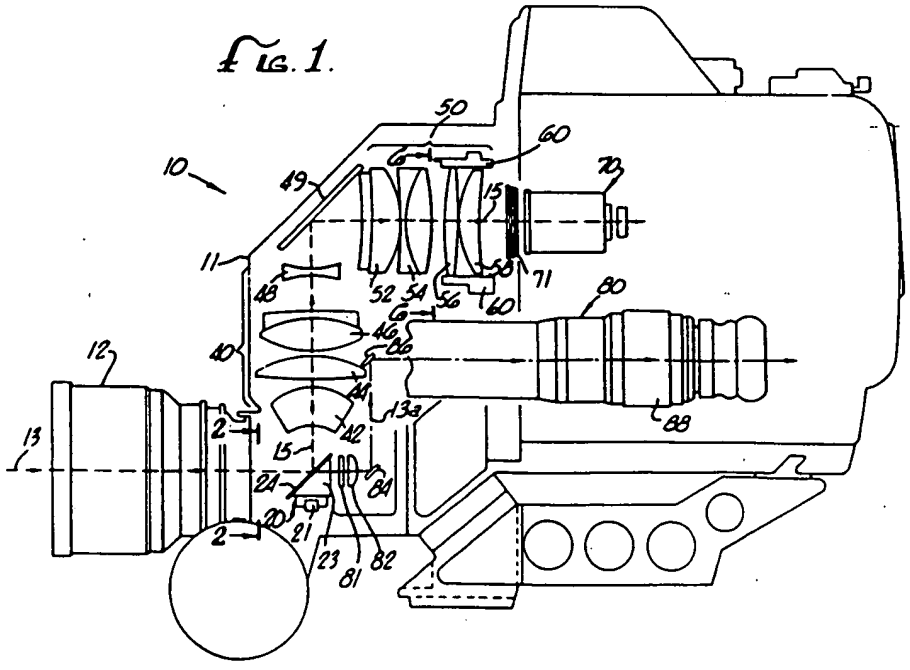
(56) Documents cited
EP 0294005 A1 US 4525745 A US 4330870 A

(58) Field of search
UK CL (Edition K) G2J J23A, H4F FCC FJL FJS
INT CL[5] G02B, H04N

# (54) Video camera having thermal compensation mechanism

(57) A camera 10 for electronic cinematography has a housing 11, an objective lens assembly 12 which is removably mounted on the housing, a video detector 70 mounted within the housing 11, and a light relay system 20, 40, 49, 50 in the housing to provide an optical path for light from the objective lens assembly 12 to the video detector 70, the light relay system having an adjustment mechanism 60 to permit refocusing of the image at the video detector 70 in response to defocusing effects. Preferably one of the optical elements 52, 54, 56, 58 nearest the video detector 70 has a position adjustment mechanism 60 associated therewith for adjusting axial position of the optical element along its optical axis 15 adjusting focus of the image at the video detector 70 independently of the focus of the objective lens 12. Viewfinder eyepiece 80 is shown.

Alternatively, the position of the video detector 70 itself may be adjusted axially to compensate for defocusing (Figs. 9 and 10).






GB 2 259 373 A

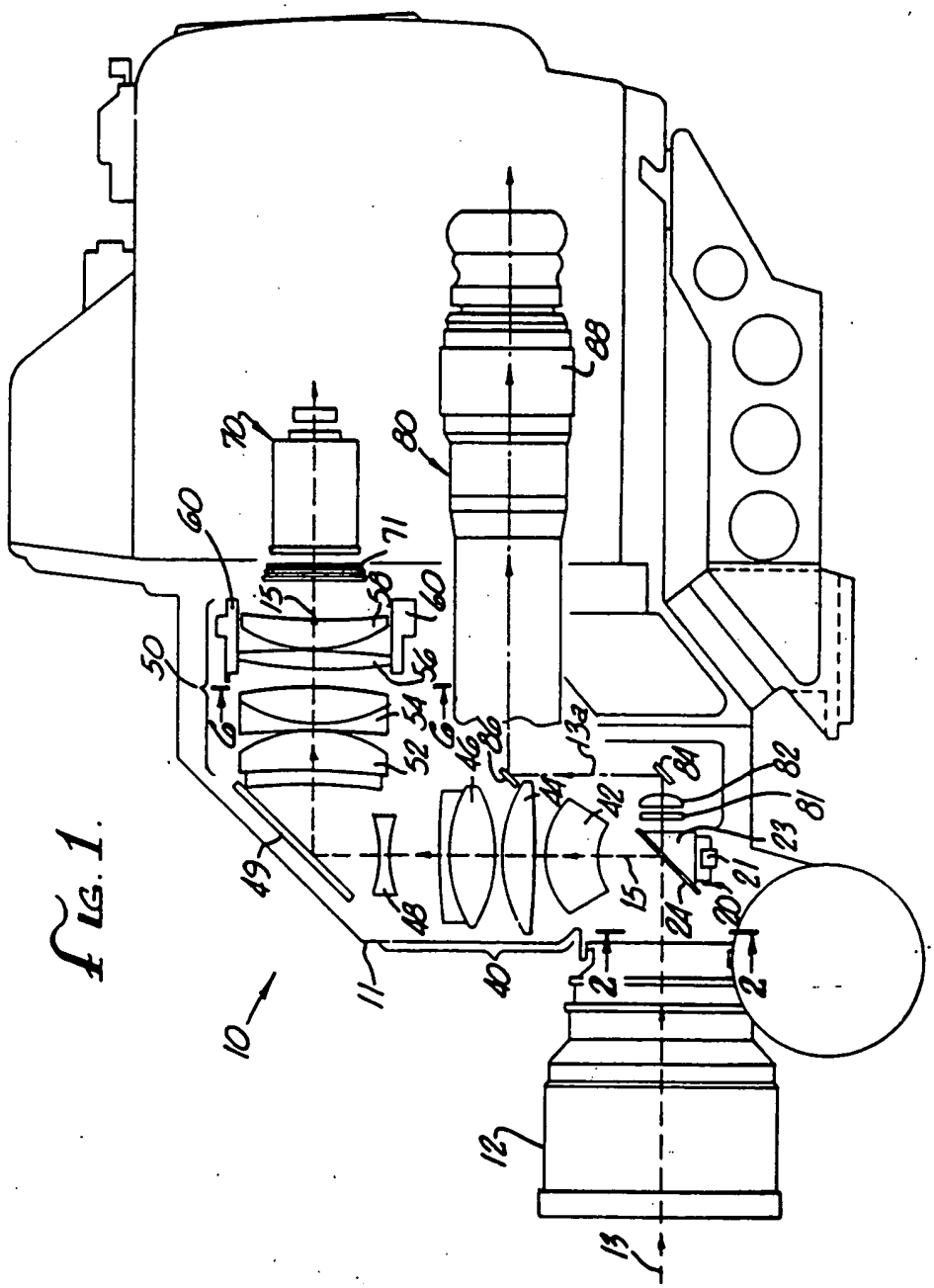

70
80
88
60
71
13
58
60
50
56
54
52
46
86
13a
84
82
81
44
42
23
49
15
24
21
20
48
40
11
10
2
2
12
13

FIG. 1.

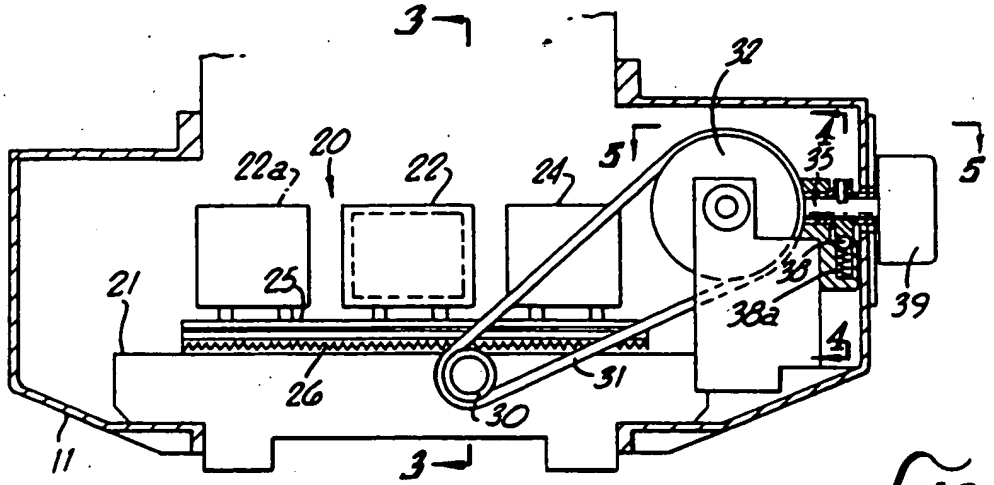

3
32
20
22a
22
24
5
5
35
21
25
38
38a
39
26
31
30
11
3

FIG. 2.

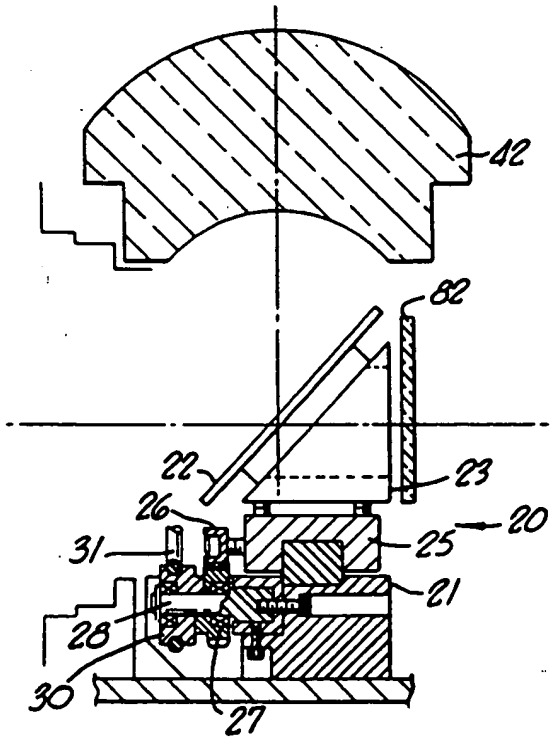

42
82
22
23
26
20
25
31
21
28
30
27

FIG. 3.

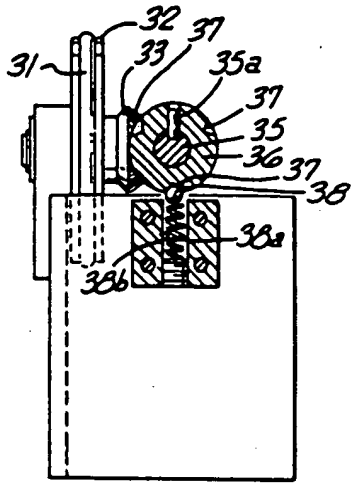



FIG. 4.

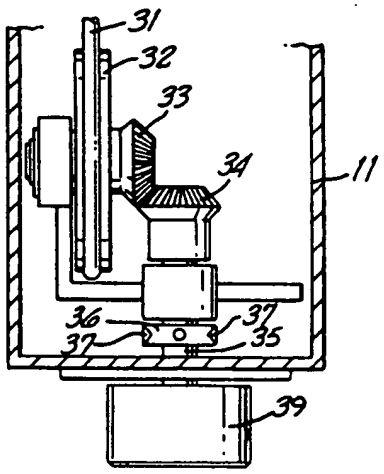



FIG. 5.

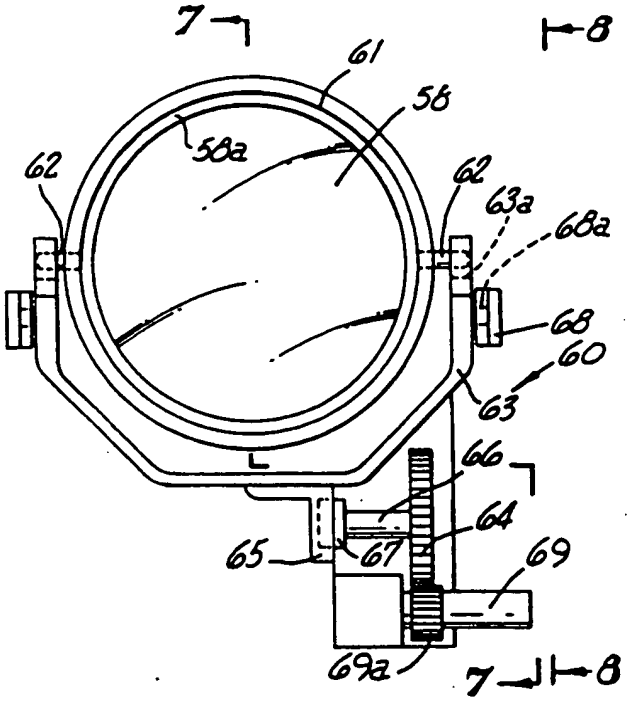

7
8
61
58
58a
62
62
63a
68a
68
60
63
66
64
65
67
69
69a
7
8

FIG. 6.

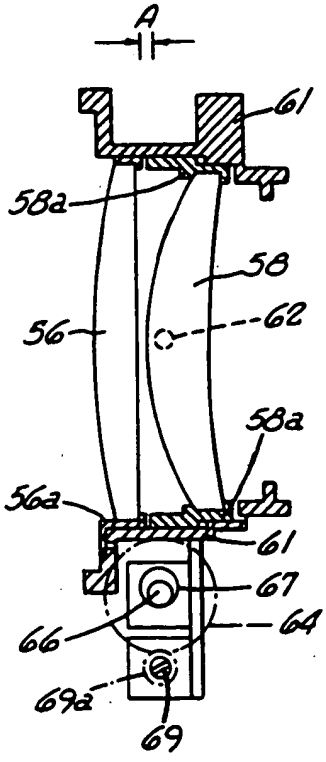

A
61
58a
58
56
62
58a
56a
61
67
66
64
69a
69

FIG. 7.

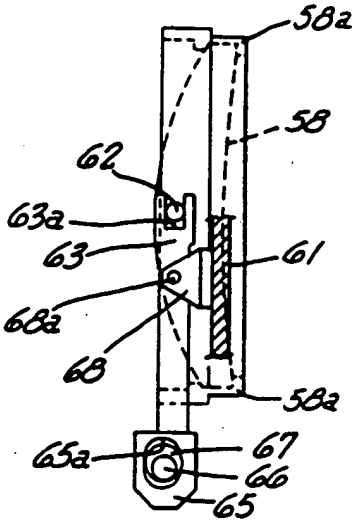

58a
58
62
63a
63
61
68a
68
58a
65a
67
66
65

FIG. 8.

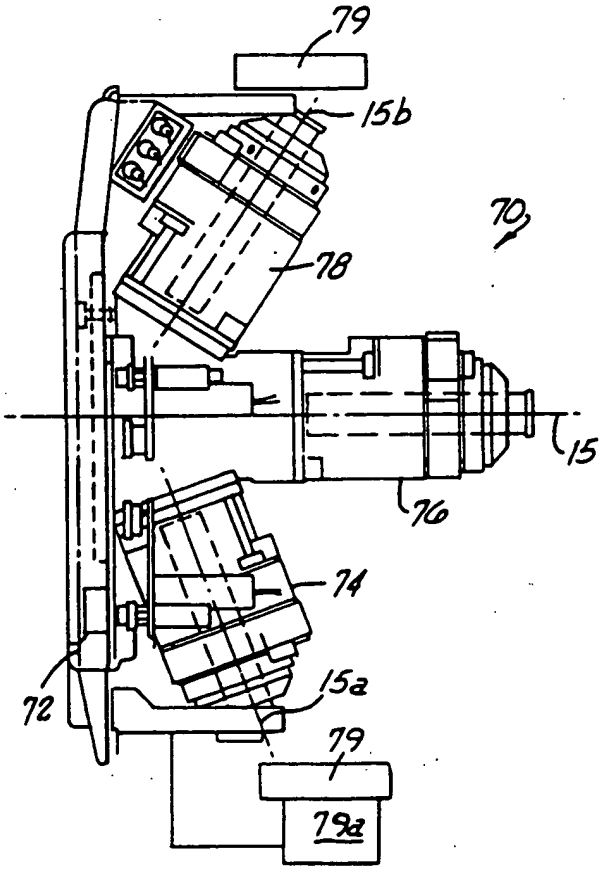
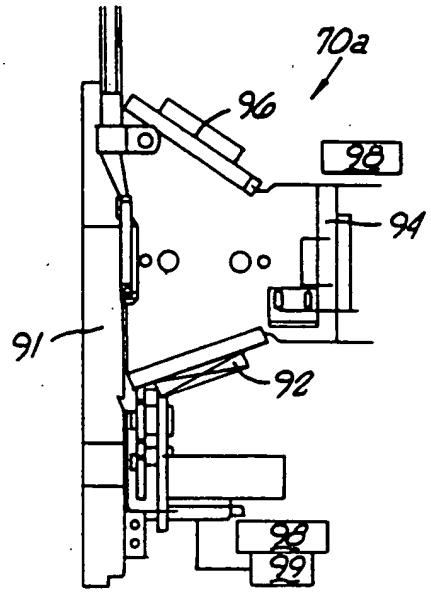

79
15b
70
78
15
76
74
72
15a
79
79a

FIG. 9.

FIG. 10.



# VIDEO CAMERA OR THE LIKE HAVING THERMAL COMPENSATION MECHANISM

## Background of the Invention

The field of the present invention relates to electronic cinematography, also known as video or video cinematography and is particularly directed to a camera device or system having a lens assembly supplying light to a video detector for recording and/or displaying on a monitor, the same lens preferably also being used for supplying light to a viewfinder eyepiece assembly. The ground glass provided in the viewfinder eyepiece assembly furnishes a large clear image which is often superior to the image provided by the television monitor. For example, the image through the viewfinder eyepiece typically has overall higher image quality assisting the camera operator to better focus or aim the camera. The viewfinder eyepiece also typically furnishes a larger field of view than the television monitor which is useful to help the camera operator better aim or move the camera. The camera assembly including the viewfinder eyepiece assembly is particularly useful for operation by cameramen skilled in operation of motion picture cameras using light-sensitive film advanced frame by frame through the camera. The television monitor is particularly useful for live action shots such as sports broadcasts.

As video technology has improved, such as the advent of high definition television, known as H.D.T.V., the present inventors have recognized that the higher definition capabilities of the electronics can also require and/or manage higher definition in the optics. Heat generated by the video detector

may affect the refocusing of the image at video detector focal planes. Heretofore the heat generated by the video detector was too small and/or the definition of the video system was too low for there to be any noticeable effect. If there was any defocusing effect noticed by the operator on the television monitor, the objective lens would simply be refocused. Alternatively, the position of the entire objective lens could be adjusted to compensate for the defocusing effect. Such focusing compensation is undesirable for several reasons. In the case where the camera system includes a viewfinder eyepiece assembly, refocusing of the objective lens would throw off the focus of the viewfinder. Additionally, the overall image quality on the television monitor is not as high as the overall image quality of the viewfinder and the camera operator would rather rely on the viewfinder for confirming proper focus than the television monitor.

Moreover, it is conventional for focusing of the objective lens to be set by measuring the distance between the focal plane and the object with the lens focusing set at the appropriate distance as indexed on the objective lens. Refocusing the objective lens to obtain an in-focus monitor image would result in error in the distance index on the objective lens. The present inventors have recognized that the defocusing occurs in the video detector itself. As the video detector heats up, elements expand changing the distance between the detecting elements and the detector reference surface resulting in defocusing. Therefore the present inventors have found it is desirable for the light relay system to have a separate focusing adjustment mechanism independent from the objective lens focusing system and independent from the optical viewfinder focus setting.

Summary of the Invention

The present invention is directed to a camera system for electronic cinematography having a housing, an objective lens assembly which is removably mounted on the housing, a video detector assembly mounted within the housing, and a light relay system in the housing to provide an optical path for light from the objective lens assembly to the video detector assembly, the light relay system having an adjustment means to permit refocusing of the image at the video detector assembly in response to defocusing effects. In the preferred embodiment, the light relay system includes a plurality of optical elements with one of the optical elements nearest the video detector assembly having a position adjustment means associated therewith for adjusting axial position of the optical element along its optical axis.

Brief Description of the Drawings

Fig. 1 is a diagrammatic plan view of a camera system according to a preferred embodiment of the present invention;

Fig. 2 is a sectional detail of Fig. 1 taken along line 2-2;

Fig. 3 is a cross-sectional view of Fig. 2 taken along line 3-3;

Fig. 4 is a cross-sectional view of Fig. 2 taken along line 4-4;

Fig. 5 is a cross-sectional view of Fig. 2 taken along line 5-5;

Fig. 6 is a detailed view of the position adjusting mechanism for optical element of Fig. 1;

Fig. 7 is a cross-sectional view of Fig. 6 taken along line 7-7;

Fig. 8 is a cross-sectional view of Fig. 6 taken along line 8-8;

Fig. 9 is a plan view of a tube type video detector; and

Fig. 10 is a plan view of a charge-coupled device type video detector.

Detailed Description of the Preferred Embodiments

The preferred embodiment will now be described with reference to the drawings. To facilitate the description, a numeral representing an element in one figure will represent the same element in any other figure.

Fig. 1 is a diagrammatic plan view of a camera system 10 according to a preferred embodiment of the present invention. The camera system 10 includes a housing 11, a detachable objective lens assembly 12 having an optical axis 13, a video detector assembly 70, and a light relay system having an optical axis 15 for providing an optical path from the objective lens to the video detector assembly 70. The light relay system is comprised of an optical relay assembly having a first mirror assembly 20, a first set of optical relay elements 40, a second mirror 49 and a second set of optical relay elements 50.

As detailed in Figs. 2-5, the first mirror assembly 20 includes a movable carrier 21 on which is mounted a support frame 23 which carries a plurality of mirror elements including a full mirror 24 and a partial mirror or pellicle 22, each of which may be brought into alignment with the optical axis 13 by movement of the carrier support 25. The mirror assembly 20 also preferably

includes an additional clear glass element or clear pellicle 22a mounted on the carrier support 25. The clear or transparent glass element 22a is of the same thickness as the partial mirror 22 in order to maintain the same light path length to the ground glass 81. The full mirror 24, the partial mirror 22 and the clear glass 22a are carried at an angle of 45° with respect to the optical axis 13. Axial movement of the carrier support 25 is accomplished by means of a gear 27 meshing with a gear rack 26 which is attached to the carrier support 25. The carrier support 25 is slidably supported on the carrier assembly 21. The gear 27 is mounted on a common shaft 28 to a driven pulley 30 which is operably connected to a drive pulley 32 by a belt 31 or other suitable flexible or articulated drive element. The drive pulley 32 is in turn mounted on a shaft common to a gear 33 which mates to a second gear 34 mounted on shaft 35 extending externally to the housing 11. An external knob 39 is attached to the shaft 35. By operation of the knob 39, the gear rack 26 may be translated so as to align the desired mirror in the light path 13.

A collar 36 is mounted on the shaft 35 just inside the housing 11 from the knob 39. The collar 36 is secured to the shaft 35 by a key 35a and also includes a plurality of recesses or detents 37 along its outwardly facing radial surface. A ball bearing 38 biased by a spring mechanism 38a within a spring compartment 38b provides for a positive lock action for the relative rotational position of the collar 36 to prevent undesirable movement of the drive mechanism once the mirror carrier support 25 is in the desired position.

The manually accessible knob 39 is mounted outside the housing 11. Alternately, a recessed actuation means comprised of a screw actuable by a screwdriver or a hexagon key wrench, for

example, may be located flush within the housing 11 so as to have no protruding knob. Other suitable drive mechanisms may be employed to translate the carrier support 25. For example, the gear shaft 28 may be turned by an electric motor actuable by a suitable switching mechanism if desired.

When either the partial mirror 22 or the clear glass 22a is aligned with the optical axis 13, light from the objective lens assembly 12 passes through the first mirror assembly 20 (referring again to Fig. 1) and is reflected through the ground glass 81 and into vertically spaced mirrors 84 and 86 in the viewfinder eyepiece assembly generally designated as 80. A viewfinder optical path 13a is thereby established from the ground glass 81, through the field lens 82, to mirror 84, to mirror 86 and to the eyepiece lens 88 to allow the image through the objective lens assembly 12 to be viewed through the viewfinder eyepiece assembly 80. The viewfinder eyepiece assembly 80 may be equipped with a movable portion to allow adjustment of the position of the viewfinder eyepiece assembly 80 relative to the camera housing 11. Such a device is disclosed in U. S. Patent No. 4,437,126 herein incorporated by reference.

When the full mirror 24 or the partial mirror 22 is positioned in alignment with the optical axis 13, light from the objective lens assembly 12 is reflected to an optical relay assembly which establishes an optical path along optical axis 15 to the video detector 70. The optical relay assembly is comprised of a first set of optical relay elements 40, a mirror 49 and a second set of optical relay elements 50. The first set of optical relay elements 40 is comprised of a plurality of optical lens elements 42, 44, 46 and 48. Similarly, the second set of optical relay elements 50 is comprised of optical lens

elements 52, 54, 56 and 58. The optical relay system includes an independent adjustment means which allows for focusing adjustment within the optical relay system independent from focusing adjustment of both the objective lens assembly and the viewfinder eyepiece assembly. In the preferred embodiment, the adjustment means is an adjustment mechanism 60 associated with a lens element within the second set of optical relay elements which adjusts the relative axial position of one of the lens elements. The preferred lens element to be axially adjusted is a lens element adjacent to the video detector 70 or particularly lens element 56, a bi-convex lens, or lens element 58, a convex-concave lens element.

Details of the preferred position adjustment mechanism for the lens element 56 will now be described in detail with reference to Figs. 6-8. Lens elements 58 and 56 are supported in the optical housing 61 by respective lens rings 58a and 56a. The lens ring 58a is constructed with a shoulder and adapted to be slidably movable within the optical housing 61 along the optical axis of the lens 58. Thus, the lens element 58 is axially translatable by an amount "A" within the optical housing 61.

The lens element 58 is moved by a drive mechanism 60 which is actuable by turning a shaft 69 which extends outward to the camera housing 11 so as to be accessible from the exterior. The shaft 69 is illustrated with a screw head so that the shaft 69 is actuable by a tool enabling the shaft 69 to be accessed but not extend outward from the camera housing 11. Alternately the shaft 69 can extend beyond the camera housing 11 and be equipped with a suitable knob.

Upon actuation of the shaft 69, a first gear 69a mounted to the shaft 69 is turned and engages a second gear 64

mounted on a shaft 66. As the shaft 66 is turned, an eccentric 67 mounted thereon also rotates. The eccentric 67 is positioned within an oblong slot 65a within bracket 65 and as it rotates, engages the edges of the slot 65a to axially translate the position of the bracket 65 from side to side as viewed in Fig. 8.

The bracket 65 is mounted to a U-shape support arm 63 which extends about either side of the lens element 58. Each end of the arm 63 is equipped with a U-shaped yoke element 63a. Tabs 62, 62 connected to the lens ring 58a of the lens element 58 extend radially outwardly through the slot in the optical housing 61 and seat within the yoke element 63a of the arm 63. Therefore as the shaft 69 and the eccentric 67 are rotated, the bracket 65 is moved laterally which in turn provides for the axial translation of the lens element 58 through movement of the arm 63 connected to the mounting bracket 65.

The position adjusting device 60 is also equipped with a tilting bracket 68 pivotally attached by a pin 68a to the arm 63 to permit pivoting of the arm 63. The tilting bracket 68 is mounted to the optical housing 61.

The present inventors have discovered that heat generated by the video detector 70, particularly in the recently developed H.D.T.V. mechanisms, causes expansion with the video detector itself producing defocusing effects at the video detector reference surface 72 (perpendicular to the optical axis 15). As this defocusing was detected by observing the TV monitor, the camera operator could refocus by focusing the adjustment on the objective lens assembly 12. In a camera system including a viewfinder eyepiece assembly 80, refocusing of the objective lens assembly would change the focus in the viewfinder eyepiece assembly 80 resulting in an image which is not in focus.

Such refocusing of the objective lens assembly 12 also throws off the focus index setting on the objective lens 12.

By incorporating an independent focusing adjustment mechanism within the optical relay system, namely the adjustment means 60, the defocusing effect due to thermal expansion may be compensated for thereby allowing the image at the video detector 70 to be adjusted into focus. By providing adjustment of the lens element 58, the defocusing effect may be compensated for without affecting the focus of the viewfinder eyepiece assembly 80 or the focus index setting on the objective lens assembly 12.

In the system of Fig. 1, the optical element selected for position adjustment would preferably be a lens element adjacent the video detector 70, such as one of the lenses 52, 54, 56 or 58 in the second set of optical relay elements 50. The lens element to be position adjusted must have focusing properties and is preferably a rotationally symmetrical lens. All of the lenses in the second set of optical relay elements 50 are rotationally symmetrical and are good candidates for position adjustment. In the system of Fig. 1, lens 58, which is the optical element (having focusing properties) nearest to the video detector 70, or lens 56 which is also near the video detector 70, would be preferred elements for axial position adjustment as these lenses are the least sensitive to aberration correction. In other relay system designs, another optical element may be the least aberration correction sensitive and it may be preferable to adjust that element to compensate for the defocusing effect.

Other methods of defocusing compensation may be employed. For example, the position of the video detector 70 itself may be adjusted to compensate for the defocusing effect. In Fig. 9, the tube type video detector 70 is illustrated as

being mounted on a carriage 79 which permits axial movement of the entire reference surface 72 and the television tubes 74, 76 and 78 along the optical axis 15. A suitable adjustment mechanism 79a associated with the carriage 79 may be employed to control the axial position adjustment of the video detector 70. In another design, details of which are not illustrated, the positions of the individual video tubes 74, 76 and 78 may be radially adjusted along each tube's axis in unison from the reference surface 72 to provide the desired defocusing compensation.

Fig. 10 illustrates another video detector 70a having charge-coupled devices (CCD's) 92, 94 and 96. In similar fashion to that described in Fig. 9, the axial position of the video detector 70a may be adjusted to compensate for the defocusing effect. In Fig. 10, the video detector 70a is illustrated as being mounted on a carriage 98 which permits axial movement of the entire reference surface 91 and the CCD's 92, 94 and 96 along the optical axis. A suitable adjustment mechanism 99 associated with the carriage 90 may be employed to control the axial position adjustment of the video detector 70a. Alternately, it may also be conceivable that the positions of the individual CCD's 92, 94 and 96 may be individually adjusted along each CCD's axis in unison from the reference surface 91 to provide the desired defocusing compensation.

As may be ascertained by the disclosure, the illustrated design delivers a reversed image to the video detector 70 or 70a. In the preferred embodiment, the image may be corrected electronically. Alternately, the image may be corrected by the addition of an image reversing optical element in the light path or a suitable modification to the optical relay

system. An imaging reversing prism is one such image reversing optical element which may be selected for reversing the image received by the reference surface 72. In addition, other suitable solid state detector devices may be employed in place of the CCD's illustrated and be provided with focus adjusting means if desired.

Other focus adjusting mechanisms may be considered. For example, one of the filter elements 71 adjacent the video detector 70 could be replaced with an optically powered element which when moved would provide the desired focusing correction.

Thus a camera system is disclosed which employs an adjustment mechanism to permit refocusing of the image at the video detector in response to defocusing effects.

# CLAIMS

1. A camera device for electronic cinematography comprising:

a housing;

an objective lens assembly removably mounted on said housing;

a video detector supported on said housing; and

a light relay system in said housing for providing an optical path for light from the objective lens assembly to the video detector, the light relay system having an optical axis and being comprised of:

a plurality of optical elements and

position adjusting means associated with at least a first optical element of said optical elements for adjusting axial position of said first optical element along the optical axis to permit focusing of the image at the video detector, independently from focusing of the objective lens assembly, to compensate for expansion or contraction of elements in response to temperature change due to heat produced by the video detector.

2. A camera device according to claim 1 further comprising:

an optical viewfinder assembly; and

means for selectively directing light from the objective lens (1) to the video detector via the light relay system and (2) to the optical viewfinder assembly.

3. A camera device according to claim 1 further comprising:

an optical viewfinder assembly;

means for selectively directing light from the objective lens (1) to the video detector via the light relay system, (2) to the optical viewfinder assembly, and (3) a portion of the light simultaneously to the video detector via the light relay system and to the optical viewfinder.

4. A camera device according to claim 1 wherein the first optical element of said optical elements comprises a rotationally symmetrical lens element adjacent to the video detector.

5. A camera device according to claim 1 wherein the first optical element of said optical elements comprises a rotationally symmetrical lens element nearest the video detector.

6. A camera system for electronic cinematography comprising:

a housing;

an objective lens assembly removably mounted on said housing;

a video detector mounted within said housing; and

a light relay system in said housing for providing an optical path from the objective lens assembly to the video detector, the light relay system having an optical axis and being comprised of:

a first mirror assembly,

a first set of optical relay elements,

a second mirror assembly,

a second set of optical relay elements, wherein said optical path is established from the objective lens assembly, to the first mirror assembly, through the first set of optical relay elements, to the second mirror assembly, through the second set of optical relay elements, and to the video detector, and

position adjusting means associated with at least a first adjustable optical element of said optical relay elements for adjusting axial position of said first adjustable optical element along the optical axis to permit focusing of the image at the video detector, independent from adjustment of the objective lens, in response to defocusing effects experienced by the light relay system; and

an optical viewfinder assembly,

wherein the first mirror assembly comprises a multi-mode means for selectively (1) transmitting all light from said objective lens assembly to the video detector via the light relay system in a first mode and (2) transmitting all light from said objective lens assembly to said optical viewfinder in a second mode.

7. A camera system according to claim 6 wherein the multi-mode means further selectively (3) transmits a portion of the light from the objective lens assembly to the first set of optical elements and a portion of the light from the objective lens to the optical viewfinder in a third mode.

8. A camera device according to claim 6 wherein said first adjustable optical element comprises a rotationally symmetrical relay lens element adjacent to the video detector.

9. A camera device according to claim 6 wherein said first adjustable optical element comprises a rotationally symmetrical relay lens element nearest the video detector.

10. A camera device according to claim 6 wherein the second set of optical relay elements comprises a first lens, a second lens, and a third lens interposed in series along the optical axis adjacent the video detector, the third lens being nearest to the video detector, the second lens being positioned between the first lens and the third lens.

11. A camera device according to claim 10 wherein said first adjustable optical element comprises said second lens.

12. A camera device such as for motion picture or video cinematography, comprising:

a housing;

a prime lens assembly removably mounted on said housing;

a video detector supported on said housing; and

a light relay system in said housing for providing an optical path for light from the prime lens assembly to the video detector, the light relay system having an optical axis and being comprised of a plurality of optical elements and a back focus adjusting means for permitting focusing adjustment of the image at the video detector, independent from focusing of the prime

lens assembly, to compensate for expansion or contraction of elements due to temperature changes from heat produced by the video detector.

13. A camera device according to claim 12 further comprising a viewfinder eyepiece assembly, wherein the back focus adjusting means permits focusing adjustment of the image at the video detector independent from focusing of the viewfinder eyepiece assembly.

14. A camera device according to claim 12 wherein the video detector comprises a tube detector device.

15. A camera device according to claim 12 wherein the video detector comprises a charge-coupled device.

16. A camera device according to claim 12 wherein the video detector comprises a solid state detector device.--

17. A camera device or camera system constructed and arranged to operate substantially as hereinbefore described with reference to and as illustrated in the accompanying drawings.